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(54) [Title of the Invention] Orthodontic Appliance

(57) [Summary]

[Object] An object of the present invention is to provide an orthodontic appliance that allows slight corrections of position and angle even after being mounted on the teeth.

[Means of Achievement] The present invention provides an orthodontic appliance using a shape memory resin (i. e., a resin selected from the group consisting of polyurethane type, polyurethane-urea polymer type, polynorbornene type, trans-polyisoprene type and styrene-butadiene type resins having a shape memory function) that has a glass transition temperature of 40 to 100°C (preferably 60 to 80°C).

[Selected Figures] None

[Claims]

[Claim 1]

An orthodontic appliance characterized in using a shape memory resin that has a glass transition temperature of 40 to 100°C.

[Claim 2]

The orthodontic appliance according to Claim 1, wherein said glass transition temperature is 60 to 80°C.

[Claim 3]

The orthodontic appliance according to Claim 1, wherein said shape memory resin is a resin selected from the group consisting of polyurethane type, polyurethane-urea polymer type, polynorbornene type, trans-polyisoprene type and styrene-butadiene type resins having a shape memory function.

[Claim 4]

The orthodontic appliance according to any of Claims 1 through 3, wherein said orthodontic appliance is an orthodontic bracket.

[Claim 5]

The orthodontic appliance according to Claim 4, wherein said orthodontic bracket comprises a construction in which a metal reinforcing body is inserted at a location through which a correcting wire of said bracket passes.

[Detailed Description of the Invention]

[0001]

[Technological Field of the Invention] The present invention relates to an orthodontic appliance, and more particularly relates to an orthodontic appliance using a shape memory resin.

[0002]

[Prior Art]

Most orthodontic appliances used for the corrective treatment of irregular teeth are used in a state in which these appliances are directly mounted on the teeth of the patient. Brackets, buckle tubes, lingual sheaths, lingual buttons and the like are known as such orthodontic appliances. Among these, orthodontic brackets are the most commonly used orthodontic appliances. A detailed description will be given below using such a bracket as an example.

[0003]

An arch form corrective wire is mounted via a ligation on an orthodontic bracket that is adhesively fastened to the teeth. The load that is generated by the bending and traction of this arch form corrective wire is applied to the aligned teeth as a corrective force, so that the teeth are moved in a specified direction, thus correcting the arrangement of the teeth.

[0004]

Here, the structure of this orthodontic bracket will be described with reference to Figures 1 and 2, using the orthodontic bracket described in Patent Reference 1 as an example.

Figure 1 is a diagram illustrating one example of an orthodontic bracket, and is a perspective view showing this bracket in a state in which the metal reinforcing body is extracted. Figure 2 shows diagrams that further illustrate the orthodontic bracket shown in Figure 1. Figure 2(A) is a plan view of this bracket, and Figure 2(B) is a side view of the bracket. In Figures 1 and 2, 1 indicates a bracket main body, 2 indicates a slot, 3 indicates wings, 4 indicates a base surface, 11indicates a metal reinforcing body, 12 indicates a base plate part, 13 indicates rising parts, 14 indicates holding grooves, and 15 indicates a circular arc shape.

[0005]

As is shown in Figures 1 and 2, the orthodontic bracket described in Patent Reference 1 is "an orthodontic bracket comprising a plastic bracket main body 1 that has a slot 2, and a metal reinforcing body 11 that has holding grooves 14, in which the abovementioned reinforcing body 11 is inserted into the bracket main body 1, this bracket being characterized in that the actual slot 2 that holds the arch wire is defined only by the metal reinforcing body 11 that is inserted into the bracket main body 1."

[0006]

Conventionally, metal brackets have been widely known as orthodontic brackets of the abovementioned type. In recent years, however, brackets formed by white semi-transparent members or transparent members, such as ceramic brackets, plastic brackets and the like, have begun to be used for the purpose of "improving the aesthetic appearance."

[0007]

Conventionally, stainless steel has been used as a material for forming metal brackets. In recent years, however, brackets made of titanium or titanium alloys have also been used. Furthermore, alumina and the like are generally used as materials for forming ceramic brackets.

However, such metal brackets are conspicuous inside the oral cavity, and thus have poor aesthetics, so that patients may dislike such brackets. On the other hand, ceramic brackets are harder than the teeth so that there is a danger that such brackets will cause wear of the opposing teeth.

[0008]

Furthermore, polycarbonates and polycarbonates reinforced with glass fibers have been widely used as materials for forming conventional plastic brackets (for example, see Patent Reference 2 and Patent Reference 3). Such polycarbonates have a high transparency and a relatively high strength, and are advantageous in that the adhesive strength required for a correction treatment can be obtained using general adhesive agents used for tooth alignment. However, the durability of such materials inside the oral cavity is poor, so that the following problem arises: namely, such materials are damaged within a year due to hydrolysis.

[0009]

In cases in which brackets are bonded to uneven crowns, these brackets are bonded in alignment with the FA point (fissure access point, a point dividing clinical crowns into two equal parts on the clinical crown axis). However, in the case of incomplete emergence or in cases in which the cut end is worn, there is a danger of misjudgment. Furthermore, positioning error occurs in cases in which the crown is largely covered with the gums so that the crown length is short, or in cases in which the slot of an aesthetic crown is hard to see. In such cases, correction of the position is impossible; accordingly, it is necessary to re-attach a new bracket after the bracket is removed. Furthermore, a method is also used in which adjustments are made by bending the arch form corrective wire; however, accurate orthodontic control is impossible in most cases. Meanwhile, in the case of strong crowding, interference with the adjacent teeth occurs, so that there are cases in which bonding in the original position is impossible to achieve. In such cases, the bracket is bonded in a tentative position, and the bracket is re-attached as the treatment progresses.

Furthermore, brackets that allow the mechanical adjustment of torque, angulation, rotation and height have also been proposed. However, such brackets have a complicated structure and are difficult to handle, or else increase the size of the apparatus, so that such products have not yet reached the finished product stage.

[0010]

Meanwhile, resins with a shape memory function (shape memory resins) have been known in the past. For example, polyurethane type shape memory resins or polyurethane-urea type shape memory resins are disclosed in Patent Reference 4; furthermore, polyurethane elastomers that have a shape memory function are disclosed in Patent Reference 5 and Patent Reference 6.

Furthermore, a polynorbornene type shape memory resin is disclosed in Non-Patent Reference 1, a trans-polyisoprene type shape memory resin is disclosed in Non-Patent Reference 2, and a styrene-butadiene type shape memory resin is disclosed in Non-Patent Reference 3.

[0011]

Such shape memory resins can be deformed into an arbitrary shape at temperatures above the glass transition temperature. These resins have the following function: namely, when these resins are cooled to a temperature that is lower than the glass transition temperature while still in a state in which the shape is deformed, the "deformed shape" is maintained "as is." Then, when the resins are subsequently heated once again to a temperature exceeding the glass transition temperature, the resins are restored to their "original shape."

[0012]

In regard to applications of the abovementioned shape memory resins, such resins are used in various types of members; for example, a "shape memory pipe body" is disclosed in the abovementioned Patent Reference 6, a "safety pin outer pin made of a polyurethane type shape memory resin" is disclosed in the abovementioned Patent Reference 7, and an "arch wire made of a shape memory resin" is disclosed in the abovementioned Patent Reference 8.

Furthermore, use in various types of medical instruments is described in the abovementioned Patent Reference 4, and the fact that "application to various fields such as various types of temperature sensors, sealing materials, ornamental materials, medial treatment materials, castings, toys, fashion materials, clothing materials, bumpers, electrical and electronic members and the like is possible" is indicated in the abovementioned Patent Reference 5.

[0013]

[Patent Reference 1] Japanese Patent No. 3364728 (Claim 1)

[Patent Reference 2] Japanese Patent Application Laid-Open No. 9-544 (Claim 6, Paragraph [0029])

[Patent Reference 3] Japanese Patent Application Laid-Open No. 7-275265 (Paragraph [0013])

[Patent Reference 4] Japanese Patent Publication No. 2003-505562 (Claims 1 through 48, Claim 73)

[Patent Reference 5] Japanese Patent No. 3344827 (Claims 1 through 5, Paragraph [0022])

[Patent Reference 6] Japanese Patent Publication No. 6-6349 (Claim 1)

[Patent Reference 7] Japanese Patent No. 3304345 (Claim 1)

[Patent Reference 8] Japanese Patent Application Laid-Open No. 63-57042 (Claims)

[Non-patent Reference 1] "Nichi-Kyoshi-shi" ["Japanese Journal of Orthodontics"], 50, pp. 147-157 (1991)

[Non-patent Reference 2] "Sentan Zairyo Oyo Jiten" ["Dictionary of Applications of Leading-Edge Materials"] Sangyo Chosakai K.K., Issued by Jiten Shuppan Center, p. 282-287 (1990)

[Non-patent Reference 3] "Shika Zairyo – Kikai" ["Dental Materials and Instruments"], Vol. 11, No. 2, pp. 196-206 (1992)

[Disclosure of the Invention]

[Problems to Be Solved by the Invention]

[0014]

As was described above, in cases in which conventional metal or ceramic brackets, or conventional plastic brackets, are fastened to the teeth, there may be instances in which these brackets cannot be bonded in the planned position. Furthermore, teeth move as orthodontic therapy progresses, so that correction of the fastening position, angle and the like is also necessary. In such cases, since correction of the position is impossible, it is necessary to remove the brackets and to attach new brackets. Furthermore, a method is also practiced in which corrections are made by bending an arch form corrective wire; in such a method, however, accurate orthodontic control is impossible. Moreover, brackets that allow the adjustment of torque, angulation, rotation, height and the like have also been proposed. In the case of such brackets, however, the structure is complicated so that handling is difficult; moreover, the size is increased so that there is an increase in the cost.

[0015]

The present invention was devised in light of the abovementioned problems and an object of the present invention is to provide an orthodontic appliance that allows slight corrections of position and angle even after being mounted on the teeth.

[Means Used to Solve the Above-Mentioned Problems]

[0016]

As means for solving the abovementioned problems (achieving the abovementioned object), the orthodontic appliance of the present invention is characterized in the use of a shape memory resin that has a glass transition temperature of 40 to 100°C. Preferably, as is furthermore described in Claim 2, this orthodontic appliance is characterized in the use of a shape memory resin with a glass transition temperature of 60 to 80°C.

Since such a shape memory resin is used, slight corrections of the position and angle can be made even after the appliance is bonded to the teeth. Furthermore, prior to bonding, even if there is some deformation, the appliance can be restored to its initial shape by heating.

[0017]

Furthermore, as is described in Claim 3, the orthodontic appliance of the present invention is characterized in that the abovementioned shape memory resin is a resin selected from the group consisting of polyurethane type, polyurethane-urea polymer type, polynorbornene type, trans-polyisoprene type and styrene-butadiene type resins having a shape memory function. By using such a resin, it is possible to provide an orthodontic appliance with the abovementioned object.

[0018]

Furthermore, as is described in Claims 4 and 5, the orthodontic appliance of the present invention is characterized in that this orthodontic appliance is an orthodontic bracket, and in that this orthodontic bracket comprises a construction in which a metal reinforcing body is inserted at a location through which a correcting wire of the bracket passes.

By thus using a shape memory resin in an orthodontic bracket, it is easily possible to correct the position or angle without any need for the new attachment of a bracket in cases in which it has conventionally been impossible to fasten the bracket in the planned position, or in cases in which it is necessary to correct the fastening position, angle or the like of the bracket due to the movement of the teeth during the course of orthodontic therapy.

[Best Mode for Carrying Out the Invention]

[0019]

Preferred embodiments of the present invention will be described below. First, however, the present invention will be described in greater detail, including the effects and merits that can be obtained in the present invention.

[0020]

As was described above, the orthodontic appliance of the present invention is characterized in the use of a shape memory resin that has a glass transition temperature of 40 to 100°C.

In the present invention, the reason that the glass transition temperature is stipulated as 40 to 100°C is as follows. Namely, if the glass transition temperature is less than 40°C, the resin strength at the use temperature inside the oral cavity is insufficient. On the other hand, in cases in which this glass transition temperature exceeds 100°C, as will be described later, this may cause problems for the teeth and mucous membranes inside the oral cavity; accordingly, such a high glass transition temperature is undesirable. The desirable range for the glass transition temperature is 40 to 100°C, which is equal to the body temperature or higher, but lower than a temperature that causes problems for the teeth or mucous membranes inside the oral cavity. This range is even more preferably 60 to 80°C.

[0021]

The reason that the use of a shape memory resin with a glass transition temperature of 60 to 80°C is even more preferable is as follows. Namely, it has been reported that the temperature inside the oral cavity is generally approximately 53°C even in the highest case. Accordingly, by setting the glass transition temperature at 60°C, which is higher than this temperature, unintentional "shape recovery of the shape memory resin" due to an elevation of the temperature inside the oral cavity can be avoided. Meanwhile, as a result of the glass transition temperature being set at 80°C or less, "trouble for the teeth or mucous membranes inside the oral cavity" can be more completely prevented.

[0022]

Thus, since an orthodontic appliance is manufactured using a shape memory resin that undergoes deformation at a temperature that causes no trouble for the teeth or mucous membranes inside the oral cavity, or at an even lower temperature, slight adjustments in the

position or angle can be accomplished by heating. The range of possible correction also depends on the shape memory resin that is used, the correctable range of the attachment position in the axial direction of the teeth is 0 to ± 0.5 mm, and the correctable range of the angle is 0 to ± 15° in terms of angulation, 0 to ± 30° in terms of torque, and 0 to ± 10° in terms of rotation.

[0023]

In concrete terms, shape memory resins such as the polyurethane type, polyurethane-urea polymer type, polynorbornene type, trans-polyisoprene type and styrene-butadiene type resins described in the abovementioned Patent References 4 through 6 and Non-patent References 1 through 3 may be cited as examples of shape memory resins that can be used in the present invention.

Furthermore, as was described above, such shape memory resins are used in various types of members; however, these applications are completely different from the intent of the present invention. Specifically, the technical contents of the applications of the shape memory resins described in the abovementioned Patent References 4 through 6 and Non-patent References 1 through 3 aim at the restoration of the resins to a stored shape. In the present invention, on the other hand, the "imparting of a shape in the vicinity of the glass transition temperature below the glass transition temperature" and the "shape recovery in the vicinity of the glass transition temperature above the glass transition temperature" that are afforded by shape memory resins are utilized.

[0024]

The abovementioned shape memory resins can be molded by injection molding or extrusion molding; in addition, molding by means of two-liquid mixing type reactive resins is also possible.

Furthermore, in the present invention, in cases in which aesthetic properties (transparency) may be sacrificed, various types of reinforcing materials (e. g., reinforcing materials such as carbon fibers, glass fibers, mineral fibers, synthetic fibers, whiskers and the like) and fillers (e. g., fillers such as calcium carbonate, talc, clay, mica, powdered quartz, powdered silica, diatomaceous earth, barium sulfate, powdered pumice, powdered polymers and the like) may be added, and coloring is also possible.

[0025]

One embodiment of the present invention is an orthodontic bracket using a shape memory resin; for example, the bracket main body 1 of the orthodontic bracket shown in Figures 1 and 2 (a bracket in which a metal reinforcing body 11 is inserted at a location through which a corrective wire passes) can be made of a shape memory resin. Specifically, this part is molded using a shape memory resin that has a glass transition temperature of 40°C to 100°C, and the shape is remembered, so that a bracket of the desired shape is manufactured. After this bracket is bonded to the teeth, the torque, angulation, rotation and the like can be altered by heating the bracket to a temperature that is higher than the glass transition temperature but lower than the molding temperature; then, the corrected bracket (see Figure 3) is obtained by cooling the bracket to a temperature that is lower than the glass transition temperature with the shape maintained "as is."

[0026]

Furthermore, the present invention is not limited to the orthodontic bracket shown in Figures 1 and 2. The present invention can be used in other orthodontic brackets, and can also be used in parts other than orthodontic brackets, such as buckle tubes, lingual sheaths, lingual buttons and the like. Such parts are also included in the present invention.

Furthermore, the abovementioned orthodontic bracket is not limited to the side of the lips (labial side), but can also be used on the side of the tongue (lingual side) as a lingual bracket.

[0027]

Next, a desirable embodiment of the present invention will be described. First, an orthodontic bracket (see Figures 1 and 2) that has a metal insert fitting (metal reinforcing body 11) is molded at 200°C using a shape memory resin that has a glass transition temperature of 60°C. Next, after this bracket is fastened to the teeth of the orthodontic patient using an adhesive agent, a wire is installed and fastened by a ligation, and an orthodontic treatment is performed. Then, at the point in time at which the wire bent by the ligation substantially assumes the shape of a straight line along the arch of the teeth as the treatment progresses, a fine adjustment of the attachment position (height), angulation, rotation, torque and the like is performed for uneven teeth. (In conventional techniques, the wire is bent by means of pliers or the like so that steps are formed or angles are applied. In such techniques, however, bending

cannot be accurately performed, so that errors are common in the finishing stage of orthodontic correction, thus prolonging the treatment period to a bothersome extent.)

Next, the abovementioned "fine adjustment of the height, angulation, rotation, torque and the like" will be described. With the bracket attached, a fine adjustment is performed by heating the bracket to a temperature of 60 to 70°C and applying a force. Then, with the shape maintained "as is," the bracket is cooled to a temperature below the glass transition temperature, so that the shape is fixed. If necessary, furthermore, the bracket can be returned to the initial molded state by reheating the bracket to a temperature exceeding 80°C.

[Examples]

[0028]

Next, an example in which a polyurethane type shape memory resin is used in the orthodontic bracket shown in the abovementioned Figures 1 through 3 will be described as an example of the present invention. However, the present invention is not limited in any way by the following description. (Furthermore, for the method used to manufacture the polyurethane type shape memory resin used in the present example, see the abovementioned Patent Reference 6).

[0029]

A bracket (see the abovementioned Figures 1 and 2) in which a metal insert fitting (metal reinforcing body 11) was inserted was manufactured by synthesizing a shape memory polyurethane prepolymer with a glass transition temperature (Tg) of 48°C using 1.0 moles of "bisphenol A + propylene oxide" and 0.81 parts of "bis(2-hydroxyethyl)hydroquinone" (as a chain extending agent) with 1.81 moles of "2,4'-diphenyl meta-diisocyanate."

[0030]

This bracket was bonded to an alumina ceramic cylinder (8 mm in diameter × 6 mm in height) used as a tooth model by means of an acrylic type adhesive agent for dental use (Ideal-1, manufactured by GAC Co., USA).

In order to vary the angle (torque) of the bonded bracket, the bracket was heated, and force was applied to the slot part so that the angle (see "α" in Figure 3) was altered to 15 degrees; the bracket was then cooled "as is" to produce a bracket with an altered angulation (see

Figure 3). Furthermore, it was possible to restore the initial shape by heating the bracket with an altered angle to 80°C.

[0031]

The movement of the teeth in a case in which the abovementioned bracket was bonded to the teeth of a dog in the upper right jaw and the angulation was corrected is shown in Figures 4(A) and 4(B). In the figures, 1 indicates the bracket main body, 2 indicates the slot, 3 indicates a wing, 21 indicates an arch wire, 22 indicates the teeth, and 23 indicates the roots of the teeth.

In Figure 4 (A), when the slot 2 and the wings 3 are subjected to a rotational correction by an angle of β in the counterclockwise direction, the arch wire 21 is bent, and a recovery force is exerted on the tooth roots 23. As a result, the teeth 22 move at an inclination angle of β in the centrifugal direction. Meanwhile, in Figure 4 (B), when the slot 2 and wings 3 are subjected to a rotational correction by an angle of γ in the clockwise direction, the teeth 22 move at an inclination angle of γ in the centrifugal direction.

[Industrial Applicability]

[0032]

By using the orthodontic bracket of the present invention, it is easily possible to correct the position and angle after bonding to the teeth in cases in which it becomes necessary to correct the fastening position, angle or the like of the corrected tooth alignment as the treatment progresses, and this bracket is advantageous in that there is no need for the new reattachment of the orthodontic appliance. Furthermore, even if deformation or the like should occurs prior to bonding to the teeth, the bracket can be restored to the original shape by heating.

[Brief Description of the Drawings]

[0033]

[Figure 1] Figure 1 is a diagram illustrating one example of the orthodontic bracket; this figure is a perspective view showing the bracket in a state in which the metal reinforcing body is extracted.

[Figure 2] Figure 2 shows diagrams that further illustrate the orthodontic bracket shown in Figure 1; Figure 2(A) is a plan view of this bracket, and Figure 2(B) is a side view of the bracket.

[Figure 3] Figure 3 is a diagram showing a bracket of the same shape as that shown in Figures 1 and 2; this figure shows a state in which the angulation of this bracket has been altered by an angle of α.

[Figure 4] Figure 4 shows diagrams illustrating the movement of the teeth in a case in which the bracket is bonded to the teeth of a dog on the right side of the upper jaw, and the angulation is corrected ; Figure 4 (A) is a diagram showing the inclined movement of the teeth in a case in which the slot and wings are subjected to a rotational correction by an angle of β in the counterclockwise direction; and Figure 4 (B) is a diagram showing the inclined movement of the teeth in a case in which the slot and wings are subjected to a rotational correction by an angle of γ in the clockwise direction.

[Explanation of Symbols]

[0034]

1 Bracket main body

2 Slot

3 Wings

4 Base surface

11 Metal reinforcing body

12 Base plate part

13 Rising parts

14 Holding groove

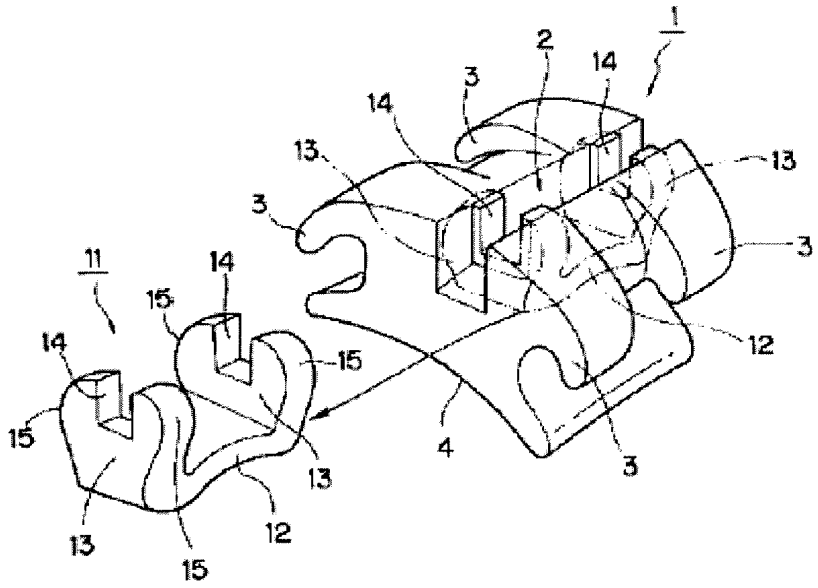
15 Circular arc form shape

21 Arch wire

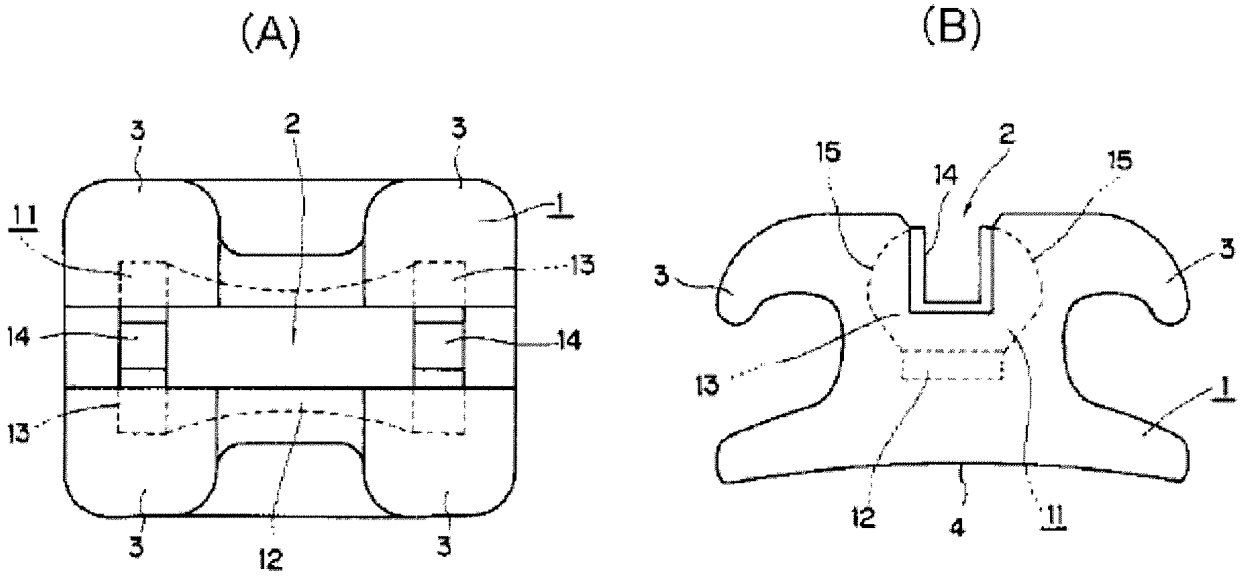
22 Teeth

23 Roots of teeth

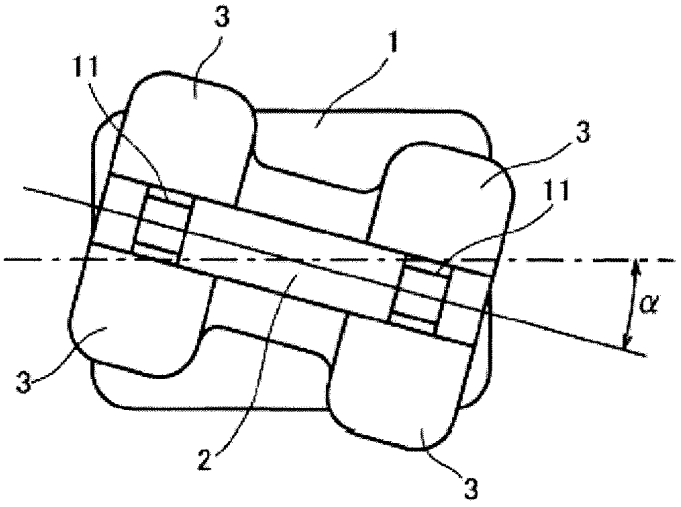
[Fig. 1]



[Fig. 2]



[Fig. 3]


3
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11
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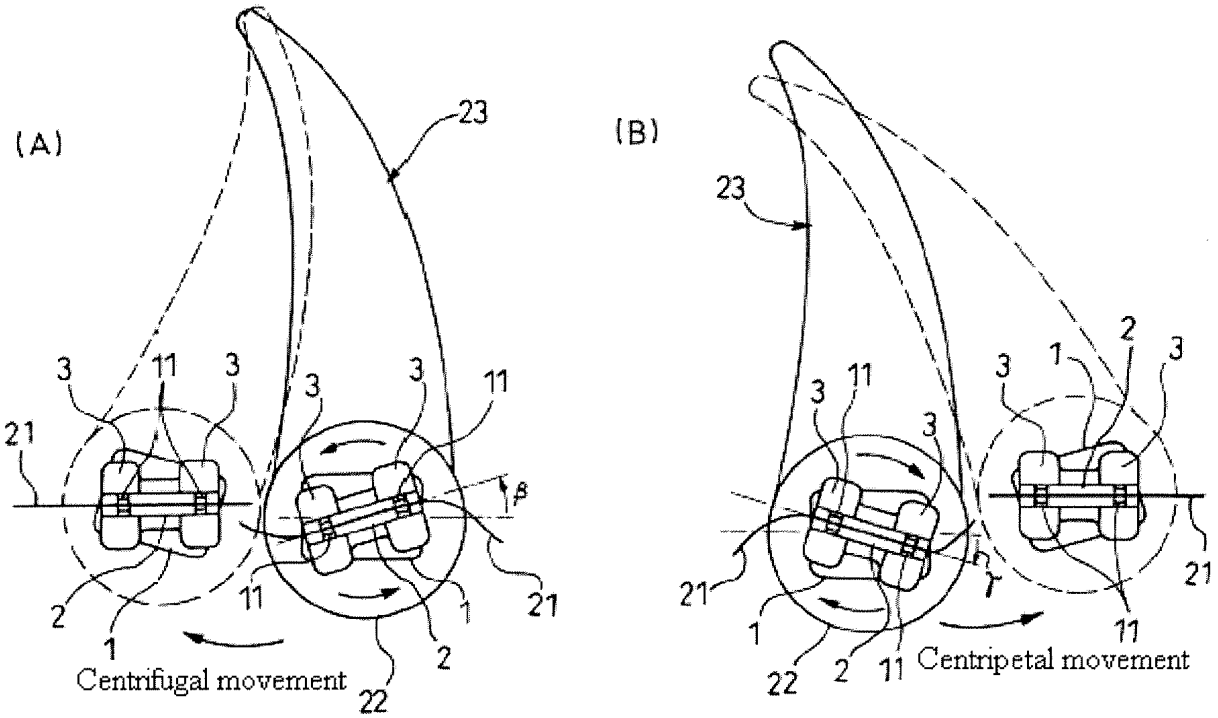
11
α
3
2
3

[Fig. 4]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